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MODERN TECHNIQUES APPLIED TO THE DESIGN AND CONSTRUCTION OF THE HIGH ASSWAN DAM

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MODERN TECHNIQUES APPLIED TO THE DESIGN AND CONSTRUCTION OF THE HIGH ASSWAN DAM

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I. RECONNAISSANCE SURVEY FOR UTILISING THE FLOOD WATERS OF THE NILE TO THE BEST ADVANTAGE

1, The flow of the river Nile, like other rivers in the world is fickle and unsteady, being governed by intricate climate conditions as yet uncontrolled by man. Its variable supply may be short of irrigation requirements as to threaten the country with the danger of stravation or may be so high as to cause destructive innundations.

2. Since a very early period the problem of harnessing the flow of the Nile for the better security and prosperity of the people of its valley has always engaged their serious attention. The problem was mainly that of regulating the flow so as to avoid the extreme fluctuation of drought and flood and of obtaining the maximum benefits inherent in its potential resources.

3. During the last one hundred years, much has been done to conserve the waters of the Nile for irrigation purposes but up to the present time a large amount of each annual flood still flows to waste into the sea. The amount passing to the sea is, however, very variable being almost nil in the lowest year and as much as 100 milliards of cubic meteres in the highest.

4, For the design of any control project on a river, accurate and detailed information about its regime of flow should be obtained. On the Nile we are more fortunate than many other countries where water development has only recehtly become important, and in many cases, only few observations covering a very short time exist.

5. In Egypt, records on the Roda Island gauge in the Nile near Cairo go back to nearly 1000 years. Though the value of its readings is considerably reduced by the difficulty in following the various repairs and reconstructions which the gauge has undergone, yet the records were good enough to give an idea of the periodicity of high and low floods. With very few exceptions, the maximum levels of the Nile at Roda were recorded for each year since it was erected up to the present day. Again the early gauge which was built at Asswan is a standard gauge indication the true state of the river level since 1869.

6. The scientific study of the Hydrology of the Nile actually began after the construction of the original Asswan Dam in 1902, when current meters were first introduced as a means of measuring

the quantity of water flowing in the Nile and for the first time the Blue Nile and White Nile were accurately measured and their relative discharge proportions discovered.

7. Many observation stations in many of the important localities along the Nile were established to collect more information about its sources. This, however, was not easy task for a river whose length exceeded 6000 kilometers going through the countries of Kenya, Tanganika, Congo, Uganda, Abyssinia, Sudan and Egypt. All these studies were conducted mainly by the irrigation department of Egypt because although the other countries are in one way or another affected by the river, none of them entirely depends on it as much as Egypt does.

8. As a result of the large number of observation stations constructed at the different reaches of the river and its tributaries for the registration of water levels, discharges and rainfall, a large amount of data has now been collected and our knowledge about the river has now increased to an extent not very far from perfection.

9. It was in the light of these observations and information that all the hydraulic structures on the river were constructed including the existing Aswan Dam, the Gabel Awlia Dam near Khartoum, the Sennar Dam on the Blue Nile, the Victoria Lake Dam and other big barrages on the Main Nile from Aswan to the Meditterranean Sea. It was on the basis of these observations also that the hydrological investigations for the present High Aswan Dam Project were successfully conducted.

10. During the last ninety years, available records of the Nile water supply revealed that the flow varied considerably from year to year. While the annual water requirments for irrigation of the present cultivated area in both Egypt and Sudan are 52 milliard cubic meters, the natural flow of the river reaching Aswan may be as low as 42 milliards of cubic meters as it happened in the year 1913-1914 or as high as 151 milliards as it happened in the year 1878-1879. Again, while the present requirements in Egypt during summer season are estimated at 22 milliards of cubic meters, the supply of the river in this season dropped to 7 milliards in the year 1914 and reached 36 milliards in 1879. These two contrasting cases explain the extent of the importance of the variations so far as irrigation requirements are concerned and make an urgent solution of this problem an imperative necessity. The only solution to these problems is to provide over-year storage by building reservoirs large enough to store the excess waters in all years to make use of them in time of shortage and in succession of low years.

11. Comprehensive surveys which were made by many competent technical authorities in Egypt have shown that there is not a single site on the Main Nile more suitable for a large capacity reservoir to store all flood waters of the river other than the site at Aswan.

12. It was therefore decided to construct a high dam at Aswan with a storage capacity of about 130 milliards of cubic meters, of which 30 milliards will be alloted for the accumulation of sediments in suspension of flood waters, 70 milliards for live storage and the upper 30 milliards for flood protection. According to calculations based on current theories of over-year storage, the live storage capacity of the reservoir is sufficient to provide a constant annual draft of 84 milliards of cubic meters of water which represent the average annual flow of the Nile at Aswan during the last sixty years of actual flow records.

As the average unavoidable losses from the reservoir is estimated at 10 milliards of cubic meters per year, the net guaranteed annual draft from the new reservoir will be about 74 milliards. According to the recent agreement made between the UAR and the Sudan, Egypt's annual share will be 55.5 milliards and that of the Sudan 18.5 milliards. At present these shares are 48 and 4 milliards respectively.

13. Further conservation projects for the waters of the river are possible on the Upper Nile reaches to deal with the clear waters, but these projects will only add at Aswan about 5 milliards of cubic meters of water, now lost annually in the swamps, but do little to equalise the variable flow of the Main Nile in flood season.

14. This shows clearly how the over-year storage of the flood waters achieved by the construction of the High Dam is an energetic approach to control the water resources of the Nile for the expansion in cultivation, production of electric power and other multiple purposes. In fact it is a large step towards the full development and utilization of the waters of the Nile to the best advantage.

II. TECHNIQUES APPLIED IN THE SELECTION OF THE DAM SITE

15. The selected site for the construction of the High Dam at about 7 Kilometers upstream of the existing Aswan Dam is ideal and looks as if it was made to order for the construction of a High Dam. It has the advantage that both its banks rise steeply from the river bed so that a dam of only moderate length would be required and at the same time has a very wide and deep valley on the upstream affording an excellent storage capacity.

16. An extensive programme of drilling boreholes in the river bed at the selected site was carried out accompanied with extraction of a big number of disturbed and undisturbed samples of the overburden materials. The undisturbed samples were extracted by the freezing method. This programme was set for investigating the overburden lying on the solid rock of the trough of the river and to determine its thickness, kind, density of stratification, permeability and to find all physical properties of the samples by performing necessary tests.

17. As a result of grain size analysis of the extracted samples, the upper stratum of the overburden consists mainly of sand and fine medium gravel. At depths below 35ms of this upper stratum, the overburden becomes particularly coarse containing but a small sand ratio. The lower stratum of the overburden consists not only of loose sand and gravel but there also exist clay lenses and petrified sand layers. The surface of the igneous rock below this stratum was found to form a U shape with the deepest point at about 210m below river bed.

18. These subsoil explorations as well as other technical investigations on the river banks revealed that the topographic, geologic and hydrologic conditions at the selected site of the dam lend themselves well for the construction of a very safe high dam.

19. For the estimation of the reservoir capacity an aerial survey covering the reservoir area was made. Control points necessary for drawing up the topographic maps of this area were fixed by the Egyptian survey department.

III. SELECTION OF THE TYPE OF THE DAM

20. At first many difficulties were associated with the design of the dam as it has to be constructed on a pervious foundation in the lake of the existing Aswan Dam where the depth of water exceeds 35m. Again, the quantity of water which will pass at the dam site during its construction may assume in flood seasons volumes up to 11,000 cu.ms. per second.

21. In fact the natural features of the site offered insurmountable difficulties in regard to the construction of a concrete dam. On the other hand, these features, as well as other conditions concerning the availability of suitable construction materials in the vicinity of the dam site, were practically favourable for the realisation of a rock-fill dam.

22. Several important problems bearing principally on the stability of the dam and on the seepage losses were carefully studied before the engineers came to the successful conclusion that a rock fill dam could safely be built at the selected site.

IV. EXPLORATION OF LOCAL CONSTRUCTION MATERIALS

23. The exploration made for the local materials of construction in the vicinity of the proposed site showed that there are enough quantities for all main materials required for the construction of the proposed rockfill dam with its central clay core. Borrow pits were excavated to explore the suitable material for the impervious core and the horizontal impervious blanket of the Dam. It was found that it can be made out of Nile silt. Large deposit of this silt is located at Bahrif Island which lies about 22 kilometers north of the proposed site of the High Dam.

24. The rock material which will be obtained from the open rock diversion canal and spillway tunnels will be used in the construction of the rockfill part of the dam. Additional required quantities of rock can be obtained from quarries within a moderate distance from the dam site.

25. Dune sand required for the upstream part of the dam is available in unlimited quantities on the west bank of the Nile. Full adequate coarse grained filter materials can be obtained by a process of crushing and screening from the tunnel muck.

26. The coarse sand required for the concrete parts and for filling downstream of the central core of the dam is available at Shellal which lies at about 10 kilometers to the north of the dam. The clay required for grouting operations can be obtained from the clay quarries in the Nubian sandstone near Aswan. The available quantities are far in excess of what will be needed.

27. All materials of construction have been subject to laboratory tests and yielded satisfactory results. The coefficient of permeability of the Nile silt ranges between 1.2×10^{-8} To 8×10^{-8} cm/sec. and its optimum moist content ranges between 20 & 26. Thus it has proved to be suitable as an impervious core material.

28. A summary of the quantities of the local materials of construction involved in the construction of the project is as follows:

Placement of rockfill	27,000,000 m^3
" " dune sand	5,500,000 "
" " coarse sand	3,500,000 "
" " Nile silt	2,500,000 "
Filters	500,000 "
Aswan clay	500,000 "
Concrete and Reinforced Concrete..	500,000 "
Total...	40,000,000 m^3

V. TECHNIQUES APPLIED TO THE FINAL DESIGN OF THE DAM

29. After very careful studies of the foundation conditions and of the proposed methods of constructing different water cut-offs it was concluded that a rockfill dam equipped with a clay core, an upstream blanket and a grout curtain with the dimensions proposed will be as safe as the safest among the existing earth and rockfill dams resting on sediments because it will be protected against piping by two lines of defence; an upstream blanket and a grout cut-off.

30. According to the proposed design, the height of the dam is 110 meters above river bed, its width at the base 1000 meters and the length of roadway at its crest is 3500 meters. It will consist of three main structures; the upstream cofferdam, the main dam and the downstream cofferdam. The upstream cofferdam will serve the function of diverting the entire flow of the Nile during the construction of the main dam into the diversion canal which is now being cut on the east bank. It will be made of rockfill slui-oed with sand. The whole extent of the foundation of the main dam will be covered with a layer of compacted dune sand. The rockfill above this layer will have a clay core made of Nile silt. In the pervious bed of the river, a grout curtain will descend to a maximum depth of about 210 meters until it strikes natural bed rock. When this grout curtain is completed, it will be about 40 meters deeper than the world's present deepest grout curtain, that under the Mission Dam in British Colombia. The downstream cofferdam will be built of rockfill to prevent deposit of silt on the river bed at the site of the main dam Together with the upstream cofferdam, it will allow for the construction of the main dam in still water and will both remain an integral part of the main dam.

31. In order to furnish adequate information concerning the practicability and efficacy of the modern techniques applied to the design and construction of the dam, the following field tests were performed on site:

a. Grouting tests by injection of different admixtures of claycement and clay-silicate grouts in the sediments forming the river bed.

b. Compaction tests in submerged dune sand-fill by the use of internal deep vibrators and by blasting.

c. Compaction tests on core material by depositing layers of Nile silt and compacting them by heavy sheep - foot and peneumatic rollers.

d. Compaction tests of the material of the upstream impervious blanket by depositing separate layers of silt and stones and vibrating them by mammoth vibrators to form a combined layer of clay rockfill.

32. All these local field tests proved to be successful and informative. The information collected during their performance revealed that the test arrangements have served their purpose to perfection and the theories used for interpreting the test results were as rigorous as one can reasonably expect.

33. Grouting test in the parts of coarse and fine sands in the river bed gave the following results:

	Coefficient of Permeability Before Injection	After Injection
Coarse Sand	2.5×10^{-2} cm/sec.	2.3×10^{-4} cm/sec.
Fine Sand	6.1×10^{-3} cm/sec.	3.6×10^{-4} cm/sec.

34. However, experience in many of grouting works in other constructions has revealed that independently of the initial permeability of the sediments and their nature, the permeability cannot be reduced below certain limit. This limit is in the vicinity of 10^{-4} cm/sec and varying according to the different cases between 5×10^{-4} to 5×10^{-5}. Therefore, it can be concluded that in terms of absolute values. the permeability of the sediments forming the river bed under the High Dam obtained after injection appears to be very near the limiting value that is possible to achieve.

35. The results of the internal vibration tests on the submerged dune sand-fill indicate that while the penetration resistance at 14m. dpth in the sand-fill under test was about 60kg/cm. it was possible, after compaction, to increase this resistance to more than 400 kg/cm at a depth of 4.5m. measured at the insertion points. The results of compaction tests by blasting revealed that in order to reach the specified penetration resistance too many blasts would be required and would therefore be less economic than compaction by vibration.

36. Compaction tests on core material by using sheepfoot rollers have shown that the best compaction was attained by depositing layers of silt not exceeding 25 cm. at a moisture content of 22-25% and compacted by 8 to 10 passes. Inferior results were obtained by using pnuematic rubber tyred rollers and vibrating plates.

37. Visual inspection after carrying out the compaction tests on the clay-rockfill material showed that all voids between stones are densely plugged with Nile silt. Laboratory tests proved that the permeability coefficient was about 2×10^{-6} cm/sec.

VI. METHODS OF CONSTRUCTION USING LOCAL LABOUR

38. The excavation of the open rock diversion canal, in itself, is a formidable job requiring the excavation of more than 9 million cubic meters of hard gran te. The higher rock cliffs at the site of the canal were blown off by the standard method of driving horizontal adits and chambers inside the rock. The charging and blasting of dynamite in these chambers enabled the removal of all the higher parts of rocks, thus forming horizontal benches at different levels. On these benches, drilling rigs are installed to drill vertical holes which are charged with dynamite for the removal of rocks.

39. For the blasted rock delivery up to the dump area, the possibility of using motor trucks or railroad transport was dicussed, but it was found that the use of railroad transport, though being technically possible, is considerably more complicated from the organizational point of view. Therefore, it was decide to use for rock transportation dump trucks with load capacity corresponding to the 4 cubic meter electric shovels now used at site.

40. Rock excavation in the main canal portions is executed in layers making successive headways. Each bench excavation begins from a cut trench 25m wide made by the face method to facilitate truck manoeuvering and for increasing the equipment capacity. The rest part of the bench is removed by side headyways. Bench height has been accepted to be 12m whose value is supposed optimal for the given conditions. Increasing of the height entails diminution of the working front and therefore prolongation of the completion time. On the other hand, acceptance of the less height of the benches would entail an extra road construction works and would decrease use of equipment and blasting factors. For the available equipment, the 12m bench height is also the most convenient considering the blasted mass collapse conditions, and from the point of view of the shovels excavation height.

41. Rock blasting in the open canal is executed by bore-hole charges method in which holes are drilled in the rock to the required depth, filled with dynamite contained in water proof cartridges, and then electrically blasted by short-delay detonators. For the proper channel walls execution, the initial excavation is provided not for the full cross section but leaving the side prisms about 2m wide for petty-holes drilling and blasting. The blasted mass is thrown down to the face bottom and, after heaping by bulldozers, is loaded by excavators into trucks.

42. The shovels operation are provided in two shifts with the third shift being released for the blasting and other auxiliary and preparative works. The total rate of progrss of work does not decrease under such regime.

43. All the rock excavated from the canal is stored in dump areas from where it will be reloaded for use in the construction of the first stage part of the dam including the upstream and downstream cofferdams.

44. The number of the local skilled labour employed for the excavation works in the open canal has reached 1400. They are of the well trained workers having the following specialities:

Metal cutting machine operators
Motor, machine, compressor, pump and dump truck operators
Black smith presser
Copper and tin smith
Fitters (elec. and mech.)
Carpenters
Elec. and gas welders
Crane operators
Drivers
Oxygen station operators
Bulldozer and tractor operators
Excavator operators
Drilling rig operators
Driller by perforators
Drill dressers
Electricians

Blasters
Tyre repair workmen

The number of specialised local labour is expected to increase to 2000 during the next few months.

45. By the conditions of rock excavation in the open canal, the parts of the canal adjoining the control tunnels could not be excavated to the bottom level before 2 years. That is why for simultaneously construction development in the spillway underground structures, work is now proceeding in driving a special transport tunnel of about 600m long. The width of this transport tunnel is 10m to accomodate 5 ton trucks for two-way traffic. The height of the tunnel is 7.5m. It was determined by drilling platform dimensions and on the account of ventilation pipes placement, where the geological break areas are crossed by the tunnel, concrete, lining of the vault is made. The part of the transport tunnel from its entrance to the crossing of the first control tunnel is driven with 10% gradient to allow for easy transportation of muck and concrete by cars. The tunnel excavation is carried out by full-face rock tunneling methods. The drilling of bore-holes is performed by high speed drills from 2 drilling platforms. The muck loading into the 5 ton dump trucks is carried out by electric excavators having a shovel capacity of 0.65 cubic meters. Drilling and loading are not executed at a time.

46. The six spillway tunnels each with a diameter of 15m, have a design excavation area of 215 square meters. Considering its great height the tunnel is excavated in two successive stages by the top-heading method. Initially the top-heading of 100 square meters area is driven, then the vault is concreted and afterwards the bench of 115 square meter area is excavated. The top-heading height is determined by the accepted shovel placement condition. Such coordination makes it possible to use for driving the bench the same shovels and trucks as those used for the top-heading. For loading the blasted rocks and their removal in both parts, the same types of electric shovels and dump trucks for excavation of the transportation tunnel are used. Rock scraping after blasting in the tunnels is performed by bulldozers. The empty trucks manoeuvering in the tunnel is executed without any auxiliary means because the tunnel dimensions are sufficient.

47. When there are separate fissures in the rock and the falls out become possible, the tunnel vault and walls are consalidated by rock bolts. These bolts are up to 3m long and 25m/m dia drill steel. They are spaced at approximately 2m in chess-board order and connected by steel plates. The fissured rock is also consolidated by spraying concrete directly on the rock or above a mesh fastened by bolts to the surface. The average thickness of the concrete layer is 5 to 10cms. but in separate cases it may be increased up to 20cms. The length of the unsound rock areas subject to consolidation by steel plates is accepted in the design to be not more than 10% of the total tunnel length. The length of the parts additionally consolidated by spraying of concrete is also accepted to be 10%.

48. The number of local skilled employed in the excavation of the tunnels is 400 and will soon reach 600. Most of these local labour workers have similer specialities as those employed in the excavation of the open canal with the addition of concreters and reinforcementworkers

49. According to the design, the rockfill forming the upstream cofferdam will be sluiced with dune sand. Also the foundation of the main dam involves the placement of a big quantity of dune sand fill. A Hydromechanized system is now used for stacking the quantity of dune sand required for sluicing and filling both parts of the dam. Four big pump units are installed on barges in the river, each capable of lifting 4700 cubic meters of water per hour at a static head of 9 atmospheres. The pumped water is delivered to the dune sand borrow-pits, existing on the west bank of the river, through 800% pipe lines equipped at their end with hydromonitors to wash out the sand from quarries and gather it in the low places and ravines in the areas. From these places the 10 to 1 water sand mixture is pumped again and delivered through 450% pipe lines to an intermediate stacking area specially arranged so that its minimum level is higher than the required level of the sand filling. This intermediate stacking has to be stocked up well in advance to avoid excessive increase in number of hydromonitors at a short period of intensive sand filling consumption.

50. The quantity of dune sand which has been so far piled in the stacking area is about 1,250,000 cubic meters out of the total quantity of 4,600,000 which is required for sand filling works. The stacked dune sand will have to be washed out again by hydromonitors and the pulp of sand and water will flow by gravity through an 800% pulp pipe made on pontoons to the rockfill body.

51. The number of local labour employed at present for the delivery of dune sand by the hydromechanization system has reached 200 well trained workers of different specialities including metal cutting operators, pump operators, blacksmiths, fitters, carpenters, painters, crane operators, bulldozer and excavator operators, wood cutting machine operators, electricians and water jet operators.

VII. MODERN TECHNIQUES APPLIED FOR OVERCOMING DIFFICULTIES IN THE CONSTRUCTION OF THE DAM IN DEEP WATERS.

52. The upstream cofferdam, which will constitute a dam across the river of 50ms high, will have its core built up of rockfill with a wedge shaped body of dune sand on its upstream side. The main difficulty in the execution of work for this structure is its formation in deep waters within the present Aswan Reservoir area, where the depth of water for a large part of the year remains at 30 to 35 meters. In flood time, however when the reservoir is empty and the depth of water is small big flood velocities do not allow placement of materials.

53. According to an old design, the cofferdam was to be erected by first laying filters under water at depth up to 35ms. This work is the most important and most difficult of all works that have to be done during the first stage of construction. However, it was found that there cannot be a reliable control over such kind of work. If small sections of the bottom are left uncovered by filter, they would be very difficult to discover at such a depth under water. After construction of the rockfill cofferdam and the head of water applied on it, the sands of the river bed at these sections may be washed away, which might lead to disasters. Also when filter material is dumped into the river, its particles will be carried off downstream. The movement of the different sizes of the particles of the filter material will vary with the velocity of the stream. This will impair the quality of the filter and make the dam less reliable.

54. In order to overcome these difficulties some changes in the design of the cofferdam have been introduced. It was decided not to lay filter layers on the river bed. The rockfill of the upstream cofferdam will be dumped without filter on the bed of the river and the cavities between the stones will be plugged with sand applied in the form of pulp. The sand will fill up all the pores in the rock and therefore placement of filters in the bottom could be dispensed with. The sand has to be dumped in the river along its entire width upstream of the dumped rockfill and a head of about two to three meters should be created on the rockfill dam to help penetration of sand by the water current through the pores.

55. Experiments have shown that the sluiced sand into the pores of the rock becomes compacted by itself and moves from higher to lower levels and that infiltration through the rock-sand body is less than that through sand alone. At the same time, it is not subject to big settlement as sandfill.

VIII. PROGRESS OF WORK

56. On the 9th of January 1960, the President of the UAR blasted the first charge of dynamite for the excavation of rock in the diversion canal. This marked the historic opening of the work in the project whose completion necessitates 8 years of digging and building. Before the official start of work was announced, however, the main enphasis on construction was the establishment of the scheme and carrying out preliminary construction works. After the inauguration date, there has been a constant direction of work to the dam site and speeding up of progress on the preparatory works, site services as well as on the permanent works in particular the diversion canal.

57. Preparation for the construction of the dam involved the extension of an access railroad to a distance of about 15 kilometers and the construction of several long hard surfaced highways of about 40 kilometers, electric supply lines at 132 kv of 12 kilometers, transformer substations and many living centres consisting of about 3000 rooms complete with water supply, drainage, electric lighting air conditioning ice plant, etc.

58. For the construction of the permanent works, big workshop installations and other site facilities were put into position. They included mechanical and car maintenance workshops, water supply systems, air compressor station, crushing and screening plant, concrete workshop and batching plant, oxygen plant, cable ways and many stores and erection yards.

59. The diversion channel on the east bank of the river is now under excavation. The total length of this channel including the upstream and downstream open rock parts, the spillways structure and the power house is 1835m. The schedule of work is pegged on making the river diversion through this canal in the spring of 1964. Up to the end of July 1962, 4.5 million cubic meters of rock have been excavated representing 50% of the total canal excavation. The present rate of excavation is about 12,000m3 per day and is expected to increase to 14,000. The quantity of the locally produced explosives which has been so far used for the excavation works reached about 1600 tons of dynamite.

60. In the middle part of the channel, work is about to be completed in the 600 meters transport tunnel leading to the six main control tunnels. The width of this tunnel is 10m. thus allowing for two way traffic of the trucks used for the removal of rock from the main tunnels. Work has already started in the excavation of two of the main circular tunnels, each of 15m diameter.

61. At the inlet of the diversion canal a temporary cofferdam of about 20m high and 250m. long was made of dune sand-fill. The filling of the 250,000m3 of dune sand forming this cofferdam was carried out by the use of the hydromechanization installations.

62. Several contracts have been awarded to contractors for the execution of the first stage works of the dam which, according to the schedule will be completed in 1964. For the excavation of the open canal and the foundation of the hydro-electric power station the construction of the upstream and downstream cofferdams, the formation of the right wing of the main dam as wall as the constuction of other ancillary works, a contract was awarded in March 1961 to a joint company of local contractors for LE. 15,760,000. Concrete works of the power station and of the intake portals of the control tunnels were entrusted to a local company specialised in concrete works for LE. 4,013,000.

63. In the meantime, investigation works including topographic and geologic studies of the routes of the electric lines for the transmission of power from the High Dam Hydro-electric Power Station to Cairo are proceeding. This network transmission scheme involves the erection of two 900 kilometers electric supply lines at 500 kv as well as 1000 kilometers of 132/220 kv lines.

64. The total cost of the High Dam Project is estimated at about LE. 215 millions of which LE.40 millions have been spent until the end of July 1962.

65. The number of Arab Engineers who are at present working on the project is 150. At the construction site at Aswan a trade school programme is established to train Arab equipment operators, technicians and foremen with special emphasis on safety. To meet all demands, the total local labour force at the construction site has exceeded 12,000 men.

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